Building Information Modelling for Work Health and Safety Management

1B

Best Practice Matrix

CONTENTS

TABLE OF ACRONYMS AND TERMINOLOGIES

AIR	Asset Information Requirements
BEP	BIM Execution Plan
BIM	Building Information Modelling/Building Information Model Interchangeable with digital model/digital modelling/digital engineering
ECI	Early Contractor Involvement
EIR	Exchange Information Requirements
HSE	Health and Safety Executive
IDMF	Infrastructure Data Management Framework
ISO	International Organisation for Standardization
Knowledge Domains	01 Scenario Planning: 02 Requirement Briefing 03 Risk Assessment: 04 Education and Training 05 Monitoring and Assurance: 06 Reporting and Analysis: Terms defined on page 8
OIR	Organisation Information Requirements
PIR	Project Information requirements
WHS	Work Health and Safety

FOREWORD

Construction is one of the most dangerous industries in which to work and many safety incidents, injuries and fatalities could be prevented through improved design, planning and communication. Building Information Management (BIM) is an enabling technology for the generation and management of digital design and construction information from which Work Health and Safety (WHS) hazards and related risks can be identified, assessed and managed. There is an opportunity for BIM to support the elimination or mitigation of risks. WHS management requires controls to be in place over the entire asset lifecycle including project planning, design, construction, end use, maintenance, decommission and demolition. BIM as an enabler of data and information management provides the opportunity to improve health and safety through better analytics, modelling and simulation with the underlying assumption that this will provide for better insights, decisions and outcomes. Data as an asset to manage is core to this suite of guide notes in the BIM for WHS Management Decision Framework.

Skye Buatava,

Director, Centre for Work Health and Safety

Scientific research is vital to improving our way of life and work health and safety is an important part of our work lives. The research that created these guidelines has the capability to put Australia on the cutting edge of safety practices in our infrastructure projects and highlights the way businesses can use BIM to improve their WHS outcomes. I'd like to thank our research partners who led with project with the Centre and also acknowledge our national and international contributors for sharing your experiences so freely with us.

Claudelle Taylor,

Enterprise Solution Managers, CIMIC

Our industry needs tools to bring BIM and WHS management together and best practice examples are key to this. We are a very competitive sector and we are often looking over our shoulder to see new ways of managing BIM. The best practice examples in this Decision Framework across the six areas give us insights on what to do and also trigger other ways we can adapt to the digital world through WHS.

Prof Kerry London,

Pro Vice Chancellor Research, Torrens Global Education

The study is an excellent example of impactful research through involving end users of research. The Decision Framework is also informed from analysis of policies and practices in other countries coupled with international research on Building Information Modelling adoption over the last decade. Australian researchers at different times have led the way in construction IT research and are certainly a leader in construction safety research. I was delighted to lead this research project and chair the Industry Advisory Group. I am deeply grateful to all those who contributed from the advisory group, the researchers at Torrens University Australia, Western Sydney University and the Centre for Work Health and Safety.

ACKNOWLEDGEMENTS

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BACKGROUND CONCEPTS

ABOUT THIS GUIDE NOTE

The Guide Note provides information derived from a research study sponsored by SafeWork NSW Centre for Work Health and Safety and completed by Torrens University Australia and Western Sydney University. The Guide supports the NSW implementation of the Infrastructure Data Management Framework and the ISO 19650 series. This guide sits within an overall Decision Guidance Framework as shown in Figure 1. The purpose of this Guide Note is to provide tips and examples on principles and processes on developing information requirements to support BIM for WHS management. While the Guide Note was commissioned for the state of New South Wales, Australia, it is suitable for other states and other countries.

- Four best practice Australian case studies
- 10 international case studies

GUIDE NOTE DOCUMENT HIERARCHY

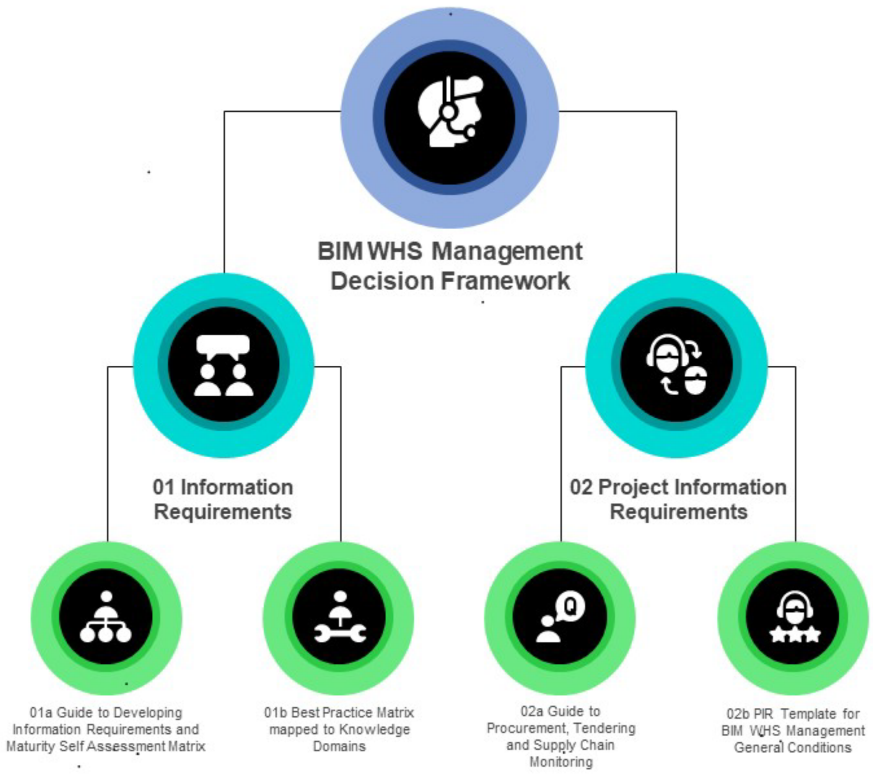


Figure 1 Guide Note Document Hierarchy

WHAT IS THE PURPOSE OF EACH GUIDE NOTE

GUIDE NOTE 01A DEVELOPING INFORMATION REQUIREMENTS

The purpose of this Guide Note is to assist leaders to collaborate to develop quality information for BIM for WHS integration. The self-assessment maturity matrix is useful to help to evaluate where you are up to in your journey of adoption of Building Information Modelling for WHS management.

In construction sectors in Australia and internationally, BIM and WHS are still treated as separate concepts and the role of structured digital information requirements in WHS management is still often overlooked. The Guide presents characteristics and practices of organisations that can lead supply chains in developing, managing and using structured digital information to improve WHS performance.

The Guide also acknowledges that client leadership is attained through journeys along different pathways. Therefore, the Guide presents resources such as a Self- Assessment Matrix and real-life examples that acknowledge different levels of attainment across the industry, while showcasing possible next steps for supply chains in different stages of maturity.

GUIDE NOTE 01B BEST PRACTICE MATRIX MAPPED TO KNOWLEDGE DOMAINS

The purpose of the Best Practice Matrix mapped to WHS Knowledge Domains is to provide specific examples to showcase different ways other clients and leadership teams have approached integrating BIM and WHS management. The example case studies are mapped across the six Knowledge Domains of Scenario Planning, Requirement Briefing, Risk Assessment, Education and Training, Monitoring and Assurance and Reporting and Analysis. Definitions of each of the Knowledge Domains is provided in the Definitions and Terminologies section of this Guide Note as well as in the Matrix.

GUIDE NOTE 02A GUIDE NOTE TO PROCUREMENT, TENDERING AND SUPPLY CHAIN MONITORING

The purpose of the Guide to Procurement, Tendering and Supply chain monitoring for BIM and WHS management is to provide tips on principles and process.

GUIDE NOTE 02B PROJECT INFORMATION REQUIREMENTS AND GENERAL CONDITIONS

The purpose of the PIR Template for BIM WHS General Conditions is to provide recommendations for developing project specific information requirements.

WHO IS THIS GUIDE NOTE WRITTEN FOR?

PRIMARY STAKEHOLDERS; INFRASTRUCTURE INFORMATION MANAGEMENT

This Guide Note is for individuals and organisations involved in developing information requirements to underpin BIM-supported projects that will pursue the integration of BIM and WHS management. Those individuals and organisation may be operating on behalf of the appointing party, lead appointed party and the appointed parties. The Guide is typically for the leadership team including; clients, facility/asset managers, project directors, project managers, design consultants, contractors and key specialist subcontractors. It is specifically aimed at **senior executive and managers** who make decisions at a strategic level on assets and project design and construction delivery. It is useful for BIM professionals seeking to develop their understanding of WHS management, as well as WHS professionals seeking to understand the capabilities of BIM.

The Guide is aimed at client organisations who wish to set the right environment and culture in relation to quality information management to support creating safe work environments during design, construction and operations.

WHO IS THIS GUIDE NOTE 'OF PARTICULAR INTEREST TO' AND WHY?

SECONDARY STAKEHOLDERS: INFRASTRUCTURE INFORMATION MANAGEMENT

This Guide Note is of interest to parties involved throughout the asset delivery lifecycle, who seek to produce reliable information requirements that meet defined purposes and enable effective delivery of information across the entire lifecycle. There are those in organisations that procure capital works, who do not work directly on projects, who have a stake in creating, using and/or managing quality information. The overall objectives of an organisation often rely upon quality information management that is well integrated to other portfolios in the organisation and the information systems that underpin these portfolios; for example, finance, human resource management, equipment procurement and asset maintenance.

BEST PRACTICE MATRIX: BUILDING INFORMATION MODELLING WHS MANAGEMENT INTEGRATION

INTRODUCTION

The Best Practice Matrix provides information derived from a research study sponsored by Centre for Work Health and Safety and completed by Torrens University Australia and Western Sydney University. The Matrix provides example case studies that showcase best practice and provide ideas to implement. The Australian case studies developed from the research study are 'real life' examples The International exemplars were developed through a literature review and are typically innovative pilots. The Matrix is for clients, asset owners and managers, consultants, contractors and subcontractors who are seeking to make a difference in WHS throughout the project life cycle.

There are six knowledge domains including scenario planning, requirement briefing, risk assessment, education and training, monitoring and assurance and reporting and analysis.

The Best Practice Matrix provides examples from projects on how BIM has been integrated to these six areas. The four Australian case studies provided leading practice examples across the Knowledge Domains.

Integrating BIM with WHS management has emerged as an important activity worldwide as exemplified by the 10 international case studies that showcase BIM application to various Knowledge Domains. The final case study identified Model use areas that could have been improved. For further information refer to Technical Reports
Centre for Work Health and Safety website:
http://www.centreforwhs.nsw.gov.au

WHAT ARE THE SIX KNOWLEDGE DOMAINS?

01-SCENARIO PLANNING:

Using BIM to develop various scenarios and options for designs, construction methodologies (particularly temporary works) and asset management regimes through visualisation and data analytics to optimise WHS management. The identification of hazards and related risks can enable elimination or preventative strategies to be analysed and implemented in the virtual world, before physical work commences.

02-REQUIREMENT BRIEFING:

Using BIM to develop WHS requirements and standards throughout the project lifecycle from inception, planning, design, construction, end-use, maintenance, decommissioning and demolition will enhance collaborations through a consistent and coherent repository of information. Crucial to developing information requirements is the management of key activities such as the design consultant briefing and the tendering phases and Model Phase handover.

03-RISK ASSESSMENT:

Using BIM to identify, assess, mitigate and communicate risks in design can reduce unsafe work environments. Hazards and related risks can be identified and appropriate controls implemented to eliminate or minimise the risks. Unsafe work environments can include both the completed asset including its end use and maintenance and the construction site environment.

04-EDUCATION AND TRAINING:

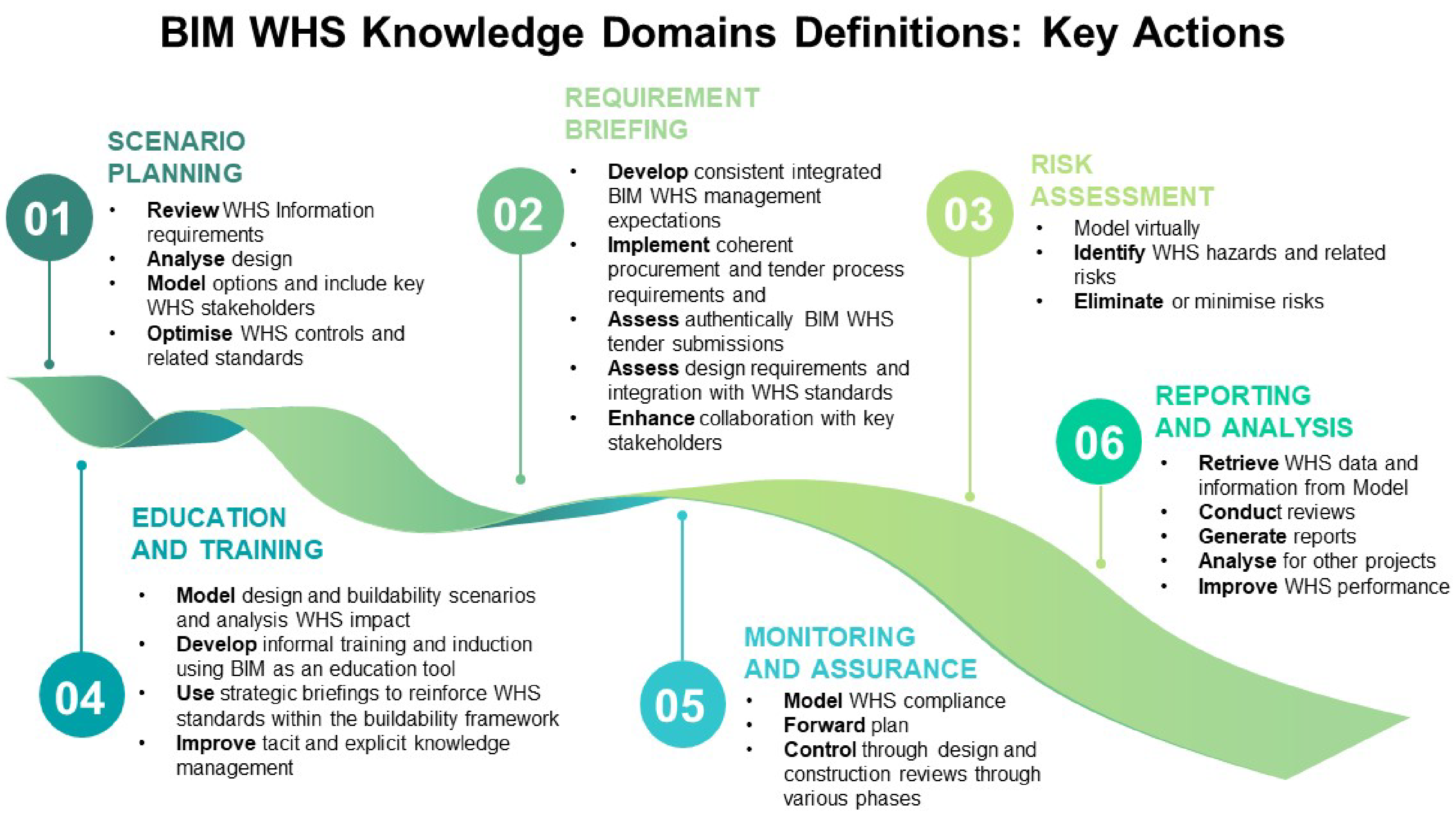
Using BIM to educate and train can involve a range of actions including; sharing design or other related information to raise awareness across different professions, paraprofessionals, consultants and trades; communicating expectations and performance; creating a community of practice; implementing formal and informal training and induction, and presenting virtual briefings to key stakeholders.

05-MONITORING AND ASSURANCE:

Using BIM to regularly monitor WHS standards can ensure a safer work culture, better forward planning and scheduling and improved management of onsite construction activities. Monitoring WHS through models during design reviews can inform practices aligned with site specific design detail, interfacing or overlapping trade activities and related WHS management.

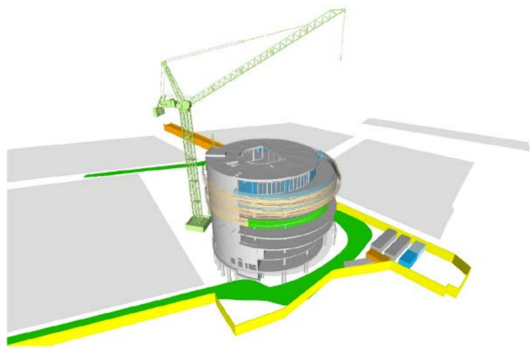
R06-REPORTING AND ANALYSIS:

Using BIM to retrieve information, conduct analyses and generate reports against WHS performance, WHS codes, regulations, standards and client requirements can reduce time devoted to these tasks. Checking can be automated and streamlined.



AUSTRALIAN BEST PRACTICE EXAMPLES

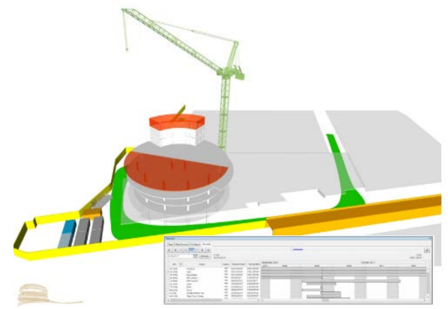
CASES		KNOWLEDGE DOMAINS					
TITLE	DESCRIPTION	SCENARIO PLANNING	REQUIREMENT BRIEFING	RISK ASSESSMENT	EDUCATION & TRAINING	MONITORING & SURVEILLANCE	REPORTING & ANALYSIS
Australian Case Study 1 COMMERCIAL BUILDING WITH COMPLEX FACADE	**ASSET**: A complex six-storey circular commercial building including a facade that was wrapped in 20 kilometres of sustainably-sourced timber strips. **CLIENT:** A multinational representing the developer, design manager and construction manager, with each function executed by a separate division. The global company refers to itself as a Global Corporate Real Estate and Investment Group (referred to as Integrated Global Corporate hereafter) **KEY BIM DRIVER:** An independent architectural consulting firm completed the concept design. The facade subcontractor was the primary catalyst for the use of BIM because of the complexity of the circular design and its façade which included externally fixed timber strips wrapped around the structure. The facade subcontractor manufactured the facade components offsite and transported them to an inner-city site for installation, which was surrounded by public domain. Careful preplanning and logistics were critical to the successful integration. BIM was key to ensure detailed design elements were visualised which included safe transportation, unloading and installation of the façade and other key design elements.	**USE CASE**: The Model was used for design planning to determine the optimum location for cranes used to install the facade. **BENEFIT:** The facade subcontractor identified critical design angles and dimensions within BIM to ensure that cranes could be positioned correctly the first time to avoid rework and related safety, time and cost implications.	**USE CASE**: The Model was used for planning detailed design and related work sequencing. Daily work activities were then shared with supervisors on site. **BENEFIT**: The facade subcontractor provided BIM-images of daily work activities, which were used by construction supervisors to brief other trade subcontractors on the site during toolbox talks about WHS management like the location and extent of exclusion zones and high risk activities, such as slinging and lifting.	**USE CASE**: The Model was used for proactively assessing design details and related buildability and sequencing including WHS risks on the site. **BENEFIT**: The facade subcontractor used the Model to identify the capacity and type of cranes required and its positioning on a weekly basis. Safety was enhanced due to improved design and sequencing of activities and communication of high risk work activities across the entire site.	**USE CASE**: The Model was used as a daily communication device. A television screen displayed how the project was progressing and explaining activities on a daily basis. **BENEFIT:** The trade subcontractors that were normally detached from the use of BIM were drawn into a community of practice making routine use of digital models for sequencing and safer site work practices.	**USE CASE**: The Model was used for demonstrating how activities would unfold over both the short-term and long term triggering a 'look ahead' planning culture. **BENEFIT**: Use of the Model reduced the tendency for trade subcontractors to rush work and develop sound work planning practices. Compliance with a work schedule that did not compromise safety was strengthened, and scheduling time pressure was alleviated.	**USE CASE**: The Model was used for conducting analysis based on multiple variables such as site parameters, fencing, temporary lifts on site and crane capacity. **BENEFIT:** Digital coordinates of temporary lifts and cranes were inputted into the model to assess if a crane of the right capacity had been selected for a given task.



Case Study 1 Pre- Construction Review

The complex six-storey circular commercial building including a facade that was wrapped in 20 kilometres of sustainably-sourced timber strips. It was a physically constrained urban site with high public visibility.

The images show the use of the BIM to determine the optimum location for cranes used to install the facade. Cranes and their use are a major source of WHS risks on construction sites. Proactive integration of WHS considerations into planning and design of crane use by using Building Information Modelling effectively reduces the potential WHS risks related to crane use. The 3D images provide a visualised tool for risk communication and training.



Case study 1 Pre-Construction Review

AUSTRALIAN BEST PRACTICE EXAMPLES							
CASES		KNOWLEDGE DOMAINS					
TITLE	DESCRIPTION	SCENARIO PLANNING	REQUIREMENT BRIEFING	RISK ASSESSMENT	EDUCATION & TRAINING	MONITORING & SURVEILLANCE	REPORTING & ANALYSIS
Australian Case Study 2 INTEGRATED METRO TRAIN STATION AND HIGH- RISE COMMERCIAL TOWER	**ASSET:** An underground metropolitan train station, pedestrian station access and over station development including two retail and commercial towers. **CLIENT:** A Global Corporate Real Estate and Investment Group (referred to as Integrated Global Corporate hereafter), which won the project through an unsolicited proposal. The Integrated Global Corporate then appointed a design and construct partner for the construction project. There were significant design and buildability interactions between the design and construct partner and the government client responsible for transport infrastructure because of the station component. **KEY BIM DRIVER:** The Government Client has over the last decade driven digital engineering in its infrastructure projects. The client has also more recently begun experimenting with innovative use of BIM in its projects.	**USE CASE:** The Model was used for visualising the design and delivery program, including temporary works. **BENEFIT:** 4D modelling was useful when areas of concern or buildability needed to be understood, such as construction of a glazed lift shaft in a challenging part of the building.	**USE CASE:** The Model was used for visualising design detail, briefing site staff and communicating how key constructability activities were to be planned and scheduled over both the short-term and long term, along with the daily requirements. **BENEFIT:** The construction supervisors used the Model during daily morning briefings. For e.g. various trade subcontractors knew where a concrete pour would be and would plan their daily operations accordingly. This level of design and buildability visualisation helped people understand what hazards and risks needed to be managed.	**USE CASE:** The Model was used for helping workers visualise the activities to be undertaken that day, during daily site briefings. This allowed construction teams to also identify potential WHS risks and management controls. **BENEFIT:** The Model was used to show potential hazards visually and allowed supervisors and trade subcontractors to understand the nature of risks related to the works in ways that have not been previously possible with less dynamic models and a paper- based approach.	**USE CASE:** The Model was used for facilitating communication of the design delivery program and its sequencing and WHS risk mitigation measures. The Model was also used for communicating high level construction methodology to a range of stakeholders. **BENEFIT:** The Model assisted in raising workers' awareness and capability in integrating WHS management. The Model provided talking points for key design details, buildability and interfacing activities and related WHS risks that had to be managed.	**USE CASE**: THE Model was used for demonstrating how activities were supposed to unfold over both the short-term and long term. **BENEFIT:** The Model was not used for formal monitoring, but appears to have supported compliance with the agreed approach and delivery program.	

AUSTRALIAN BEST PRACTICE EXAMPLES

CASES		KNOWLEDGE DOMAINS					
TITLE	DESCRIPTION	SCENARIO PLANNING	REQUIREMENT BRIEFING	RISK ASSESSMENT	EDUCATION & TRAINING	MONITORING & SURVEILLANCE	REPORTING & ANALYSIS
Australian Case Study 3 HOSPITAL BUILDING FOR ACUTE SERVICES	**ASSET:** A hospital building to include acute services (adult emergency, expanded intensive care and new inpatient wards), the first phase of a larger campus redevelopment. **CLIENT:** The government client responsible for health infrastructure. The client had appointed an architectural consulting firm to create the design. A large contractor, also involved in the design phase, was appointed as the construction contractor. **KEY BIM DRIVER:** The client requires supply chain partners on projects over $100M to use a specific database management tool. Use of the database ensures compliance with predefined specifications for numerous building elements. These specifications are compliant with design and related safety standards.	**USE CASE:** The 4D model could have been be used for supporting the client's Construction BIM Management Plan, indicating construction sequencing and workflow. **BENEFIT:** The 4D model could support design planning, anticipating WHS risks to be eliminated or managed by ensuring that design and related works sequencing is optimised.	**USE CASE:** The Model was used for briefing site staff and communicating how works activities were to be planned and implemented through "time lapse" presentations as well as "fly-throughs". **BENEFITS:** The Model was used during high-risk design review workshops to communicate through a virtual setting on how work should be done in relation to risks.	**USE CASE:** The Model can be used for identifying design parameters, buildability and sequencing and related WHS risks for construction, particularly during high risk construction work safety reviews and concept and detailed design reviews. **BENEFIT:** The Model could support improved assessments of the design buildability and sequencing of construction and related WHS management., in contrast to binary assessments that classify these as "compliant" or "non-compliant".			**USE CASE:** The Model could have been used to support the client's detailed safety incident reporting process. **BENEFIT:** Information from the database could aid in investigating safety incidents providing comprehensive reports to explain incidences. The Model could provide information on alternative work practices and prevention strategies.

AUSTRALIAN BEST PRACTICE EXAMPLES							
CASES		KNOWLEDGE DOMAINS					
TITLE	DESCRIPTION	SCENARIO PLANNING	REQUIREMENT BRIEFING	RISK ASSESSMENT	EDUCATION & TRAINING	MONITORING & SURVEILLANCE	REPORTING & ANALYSIS
Australian Case Study 4 CRANEAGE SOLUTIONS FOR A 75-STOREY MIXED USE BUILDING	ASSET: A 75-storey mixed-use building in Sydney. The building with over 300 hotel rooms and suites, as well as luxury residential apartments, restaurants, bars, premium retail outlets, pool and spa facilities. CLIENT: One of Australia's largest entertainment groups operating resorts in three Australian states while maintaining holdings in the UK. The entertainment group hired Integrated Global Corporate Real Estate and Investment Group (referred to as Integrated Global Corporate hereafter) as the main contractor. Integrated Global Corporate then hired a crane subcontractor. KEY BIM DRIVER: The building, which has a complex structural design, is located in a restricted waterfront area between the Sydney harbour and another construction site. The construction methodology involved extensive heavy lifting of structural elements and required robust craneage solutions. For example, one of the craneage challenges was the need to remove a large crane with a 46-metre boom, which had been at the top of the structure for 27 months. Integrated Global Corporate had considered an earlier craneage solution which did not address the dual demands of working at height, in a high wind area.	USE CASE: Integrated Global Corporate contacted the crane subcontractor to develop a solution that would speed up the construction program without compromising on safety or quality. Modelling enabled the subcontractor to develop crane recovery scenarios and select the optimal crane recovery solution in an iterative design/modelling process with structural engineers. BENEFIT: Through BIM, the subcontractor visualised how the crane would be dismantled whilst addressing issues. For e.g., it was anticipated that crane dismantling around the building maintenance unit at the top of the tower would be difficult, visualisation enabled adequate clearance to be taken into consideration prior to erection. The Model was also used to visualise how crane components could be lowered down the side of the building without it spinning or crashing into the sides of the structure.	USE CASE: The Model was used by the crane subcontractor, in collaboration with the main contractor and the client, to address other general craneage issues such as where cranes should be located, what possible clashes were, and what potential issues could be encountered. Once crane solutions were developed, these were shared with the main contractor, as input to the design and construction methodology. BENEFIT: The development of craneage solutions led to a refinement of construction methodology. Craneage solutions and construction methodology are linked. The crane subcontractor was able to influence and interrogate the scope of the project. The crane subcontractor team was given ongoing opportunities to constructively question why the main contractor had made certain decisions i.e. "why they do what they are doing" and, when necessary, to propose changes.	USE CASE: The Model was used by the crane subcontractor to develop a crane solution with a reduced number of lifts. One task originally involved lifting then installing a 30-metre, 100-tonne beam in four pieces. The original solution was risky: involving multiple lifts and also requiring propping up the four pieces, setting up scaffolds and temporary works and assembling the pieces at height. BENEFIT: By using the Model, the crane subcontractor was able to identify and assess the WHS risks associated with the original solution and come up with an alternative solution that involved using larger cranes to lift one fully fabricated beam. The solution eliminated the need for temporary works, reduced the hazards of multiple lifts and achieved significant savings in time and labour costs.	USE CASE: The subcontractor used the Model to initiate critical conversations with the main contractor about their selected construction methodology. The main contractor was given the opportunity to rethink about some important questions: what size of components they wanted to build with, how they wanted to build, what alternative methodologies were available to achieve project goals. Both parties kept communicating openly, proposing solutions and getting feedback on an ongoing basis. BENEFIT: The collaborative process combined subcontractors' expertise in cranes and the main contractor's expertise in construction and engineering. Because of this knowledge-sharing, solutions that had been previously discounted or overlooked ("we can't do that") were re-considered, through the guidance of the subcontractor.	USE CASE: The subcontractor used the Model to interrogate the notion of a single, traditional pathway towards project goals; i.e. multiple small cranes to achieve the construction program. The crane subcontractor used BIM to open up alternatives; i.e. larger cranes, better outcomes, which were then monitored through the use of BIM. "Monitoring" came after productive interrogation of a narrowly-defined solution predetermined by the client. BENEFIT: The use of BIM allowed the crane subcontractor to monitor the implementation of complex craneage solutions, for example the crane recovery system.	USE CASE: The subcontractor used the Model to analyse the right type of crane to use at the top of the building. Through detailed analysis, a decision was made to use a large, high-speed capable of lifting 25 tonnes in one lift, as opposed to the traditional solution of using multiple smaller cranes. BENEFIT: The decision to use a large crane again resulted in fewer lifts, reduced WHS risks and a construction program that was significantly de-risked. The case study showed the benefits of developing craneage solutions that are driven by detailed design. In the past, cranes had been selected with inadequate consideration of design issues. The outcome was choosing the wrong crane types which eventually imposed limitations on construction methodology, at times leading to costly changes in design. The use of BIM thus supported supported a safer, more efficient construction methodology.

INTERNATIONAL BEST PRACTICE EXAMPLES

CASES		KNOWLEDGE DOMAINS					
TITLE	DESCRIPTION	SCENARIO PLANNING	REQUIREMENT BRIEFING	RISK ASSESSMENT	EDUCATION & TRAINING	MONITORING AND ASSURANCE	REPORTING & ANALYSIS
Automatic safety checking system (US)	A rule-based checking system for safety planning and simulation by integrating BIM and safety. The system informs construction engineers and managers by reporting, why, where, when, and what safety measures are needed for preventing fall-related accidents before construction starts.	Determining potential fall hazards and scenarios by acquiring the corresponding spatial and geometric information of each object such as holes in slabs, leading edges on a floor slab, and wall openings			Potentially supporting training of employees by using the identified hazards in training programs and workshops.		Automatically analysing a building model for safety hazards and deriving the required parametric data in order to apply safety rules.
BIM-integrated management of occupational hazards (Spain)	A methodology to integrate the requirements of the Spanish WHS regulations in the design phase of building projects using BIM. This facilitates the integration of H&S into BIM methodology.		Facilitating collaborative work between the different disciplines involved in the design phase.	Determining the final risk level after the application of the measures, thus enhancing continuous improvement and reducing losses.		Allowing the requirements established by the Spanish H&S regulations to be fulfilled at the level of the development of mandatory documents.	Parameterising BIM objects, including preventive measures according to the regulations that regulate them.
Implementation of BIM in a Road project (UK)	An example of the implementation of BIM by the Skanska Balfour Beatty Joint Venture and Atkins on the upgrade of selected sections of the M25 in London. Firstly, all existing infrastructure was modelled in 3D with specific details. This 3D model was then integrated in AutoDesk Navisworks and an automatic clash detection function helped identify conflicts.			Identifying and eliminating hazards before any work begun.	Facilitating training and everyday briefings on site and enhancing creation and sharing of knowledge and understanding of WHS hazards and risks.		Evaluating the impacts of the design on WHS.
BIM-based dynamic scaffolding design and safety prevention (Australia)	A BIM-automated approach to reduce or eliminate the compliance issues in scaffolding engineering. The case study demonstrates a commercially available BIM system that dynamically generates scaffolding design by considering the design and WHS rules and regulations and reacts to the real-time modification of project features for fall prevention purpose.	Driving scaffolding design and identifying the unprotected leading edges, holes, and opening in scaffolding.	Establishing a shared understanding of project-specific requirements and presenting users choices as explicitly-defined input parameters; allowing the design intent to be communicated to different stakeholders.	Potentially reducing WHS risks that are related to scaffolding and fall from height.			Providing users with control over input parameters relating to the scaffolding system and applicable design codes and construction standards.
8D BIM modelling for WHS (Australia)	A computer system that applies the Prevention through Design concept in 8D model. 8D model is an extension of BIM, which incorporates multi-issues of design information generated and required throughout a building project lifecycle, such as time, cost, facilities management, sustainability and safety.		Potentially facilitating briefing and communication of WHS requirements throughout project lifecycle.	Performing hazard audits on models and producing hazard profiles for elements rated with three levels of severity ratings; critical, moderate and low.	Potentially supporting training of employees and guiding WHS orientations.		Potentially being used to analysing impact of design on WHS and WHS performance.
4D BIM for construction safety planning (Finland)	Solutions for the planning and management of construction site safety using more dynamic 4D models. BIM-based site layout and fall protection planning, as well as use of BIM for risk assessment, orientation guidance and safety communication are considered to be the development areas related to BIM and safety.	Including the temporary safety related parts in 4D planning and visualisation.	Facilitating briefing and communication of requirements about site layout and fall protection.	Informing assessment of risks that are related to site layout and fall protection planning.	Potentially supporting training of employees and guiding WHS orientations by demonstrating site layout and fall protection planning.		Calculating the needed safety railing quantities from the model.

INTERNATIONAL BEST PRACTICE EXAMPLES

CASES		KNOWLEDGE DOMAINS					
TITLE	DESCRIPTION	SCENARIO PLANNING	REQUIREMENT BRIEFING	RISK ASSESSMENT	EDUCATION & TRAINING	MONITORING & SURVEILLANCE	REPORTING & ANALYSIS
Automated safety risk recognition mechanism for underground construction (China)	An automated safety risk recognition process based on BIM which is generally composed of three parts: (1) building the risk database; (2) analysing the relation between engineering information and safety risks; and (3) automated safety risk recognition mechanism in the BIM platform.	Identifying technical, geological and environmental risks for underground construction and then storing the safety risk knowledge in the BIM-cloud.		Establishing a safety risk knowledge database and automating the process of risk recognition based on BIM.			
4D-BIM-Based Workspace Planning for Temporary Safety Facilities (Korea)	Automatic workspace planning for temporary safety facilities (TSF) based on construction activities, which is a systematized approach for construction SMEs to practice WHS. By using building information modelling (BIM) and add-in algorithm, safety facilities can be simulated and visualized to integrate into the designated workspace.	Identifying serious hazards related to activities and their corresponding safety measures and providing visual safety planning with semi-automatic schedule-linked temporary safety measures.	Potentially facilitating briefing and communication of requirements about temporary safety facilities.	Informing assessment of risks that are related to temporary safety facilities	Potentially supporting training of employees and guiding WHS orientations by demonstrating temporary safety facilities.		

SOURCE MATERIAL:

Automatic safety checking system (US)	Zhang, S., Teizer, J., Lee, J. K., Eastman, C. M., & Venugopal, M. (2013). Building information modeling (BIM) and safety: Automatic safety checking of Construction models and schedules. *Automation in Construction, 29*, 183-195.
BIM-integrated management of occupational hazards (Spain)	Cortés-Pérez, J. P., Cortés-Pérez, A., & Prieto-Muriel, P. (2020). BIM-integrated management of occupational hazards in building Construction and maintenance. *Automation in Construction, 113*, 103-115.
Implementation of BIM in a Road project (UK)	Health and Safety Executive (HSE). (2018). *Improving Health and Safety Outcomes in Construction Making the Case for Building Information Modelling (BIM)*. Retrieved from https://www.hse.gov.uk/construction/lwit/assets/downloads/improving-health-and-safety-outcomes-in-construction.pdf
BIM-based dynamic scaffolding design and safety prevention (Australia)	Shou, W., Hou, L., Wang, J., & Wang, X. (2015). Case studies of BIM-based dynamic scaffolding design and safety prevention. *Proceedings of 2nd International Conference on Civil and Building Engineering Informatics* (ICCBEI 2015) Tokyo, Japan, 54-56. Retrieved from https://sbenrc.com.au/app/uploads/2013/10/Publication-3-27-2_CASE-STUDIES-OF-BIM-BASED-DYNAMIC-SCAFFOLDING-DESIGN-AND-SAFETY-PREVENTION.pdf
8D Modelling for WHS (Australia)	Kamardeen, I. (2010), 8D BIM modelling tool for accident prevention through design, in ARCOM 2010 : Proceedings of the 26th Annual Association of Researchers in Construction Management Conference, ARCOM, Reading, Eng., pp. 281-289.
4D BIM for construction safety planning (Finland)	Sulankivi, K., Kähkönen, K., Mäkelä, T., & Kiviniemi, M. (2010). 4D-BIM for Construction safety planning. Proceedings of *W099-Special Track the 18th CIB World Building Congress*, Salford, United Kingdom, 117 - 128. Retrieved from https://www.irbnet.de/daten/iconda/CIB_DC24339.pdf
Automated safety risk recognition mechanism for underground construction (China)	Li, M., Yu, H., & Liu, P. (2018). An automated safety risk recognition mechanism for underground Construction at the pre-Construction stage based on BIM. *Automation in Construction*, 91, 284-292.
4D-BIM-Based Workspace Planning for Temporary Safety Facilities (Korea)	Pham, K-T., Vu, D-N., Hong, P.L.H. & Park, C. (2020). 4D-BIM-Based Workspace Planning for Temporary Safety Facilities in Construction SMEs. International Journal of Environmental Research and Public Health, 17, 3403; doi:10.3390/ijerph17103403.
Phase 1 Report – Health and safety management using Building Information Modelling	London, K., Pablo, Z., Kaur, G., Varhammar, A., Feng, Y., & Zhang, P. (2020). Health and safety management using Building Information Modelling: Phase 1 report, Government of New South Wales. Retrieved from https://apo.org.au/node/309518.
Phase 2 Report - BIM WHS management empirical study towards a Decision Framework	London, K., Pablo, Z., Feng, Y., Rahnamayiezekavat, P, Varhammar, A., & Zhang, P. (Forthcoming). BIM WHS management empirical study towards a Decision Framework: Phase 2 report, Government of New South Wales.